TUNABLE OPTICAL SOURCES

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I. RESEARCH OBJECTIVES

The purpose of this contract is to conduct investigations of materials and techniques leading to the realization of tunable coherent light sources. During this period we have investigated the various possible approaches of constructing a CdSe parametric oscillator tunable from 1.3 μ to 13 μ in the infrared and have proceeded toward an experimental verification of this type of parametric oscillator.

II. CdSe PARAMETRIC OSCILLATOR PROGRESS TO DATE

A. Investigations of various pumping sources (R.L. Byer & R.L. Herbst)

Since the last report we have spent a considerable time evaluating the CdSe parametric oscillator and its potential performance and optimum pump source. This has led to two very significant discoveries, (1) that the CdSe oscillator has a very useful tuning curve when pumped with a tunable pump source such as a $LiNbO_3$ oscillator, and (2) that CdSe does phasematch under proper pressure for up conversion of 10.6 μ with 1.32 μ of Nd:YAG to a 1.19 μ wavelength. Since 1.19μ is with the image converter range and since 1.32 μ is a very efficient Nd:YAG line this up conversion process can be potentially a very useful one. In the following discussion the CdSe parametric oscillator will be considered since the preliminary experimental work on the 10.6 μ up conversion is now being considered and has yet to be performed.

The possibility of using a $LiNbO_3$ tunable pump source from a parametric oscillator led to the generation by computer of the tuning curves shown in Fig. 1. These tuning curves show that a 90° phase matched CdSe parametric

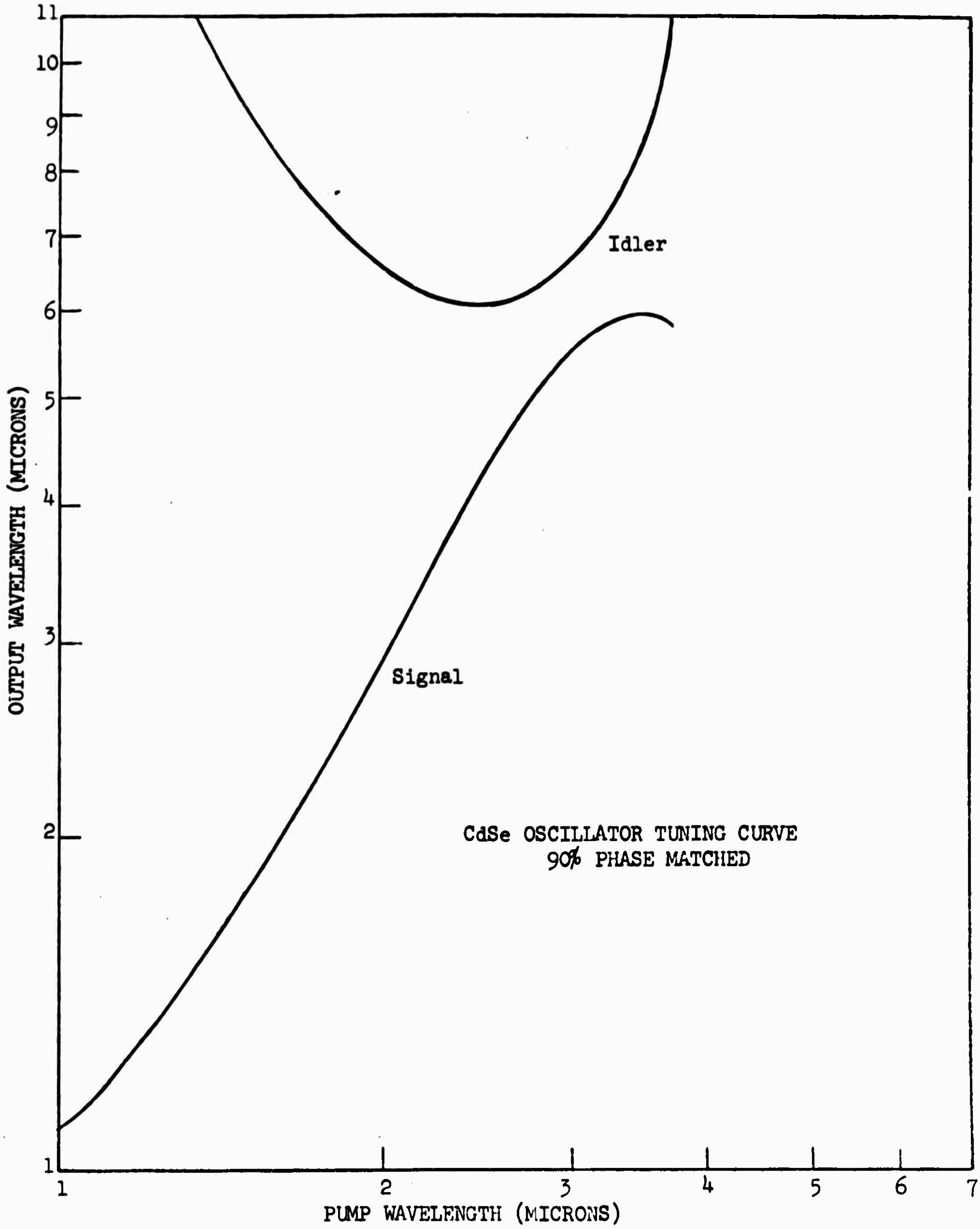

FIG. 1--CdSe tuning curve (90° phasematching) with a variable frequency pump.

oscillator can tune from 1.3 μ to 13 μ across the infrared if pumped by radiation from 1 μ to 3 μ in the infrared. The oscillator would consist simply of a crystal within an optical cavity without temperature or angle variations necessary to achieve tuning. In practice, the addition of a CdSe crystal to a $LiNbO_3$ parametric oscillator would extend the tuning range over the middle infrared.

In the last report we mentioned the possibility of using an alternative pump source for the CdSe oscillation. Since then Dr. Wallace at Chromatix Corporation has built and tested a $LiNbO_3$ oscillator pumped with a doubled 1.32 micron Nd:YAG laser. This oscillator which tunes from 0.9 to 2.7 microns and has a peak output power of 500 watts is immediately available as a pump source for our CdSe oscillator. The tuning curve is shown in Fig. 2 for reference. Since the pulse length of this oscillator is very short (100 ns) a calculation was made on the buildup time of the CdSe oscillator in both the single resonant and double resonant configurations to see if this pulse length allowed enough time for the oscillator to build up to maximum output. Using 120 dB as the gain necessary to raise the oscillator signal from noise to its maximum value and a cavity length of 5 cm we find that the buildup times for the single resonant and double resonant oscillators are respectively 34 ns and 19 ns.

With these very favorable results and the previous threshold values of 2 watts for a DRO and 100 watts for a SRO we have proceeded as rapidly as possible to collect the necessary components. In doing so we have run into some unexpected problems with both CdSe crystals and oscillator mirrors. In collecting components for the oscillator, CdSe crystals were ordered on a consignment basis from two companies, Crysteco and Clevite. This was done to insure at least one good crystal. A simple procedure was then set up to check the quality of the crystals received.

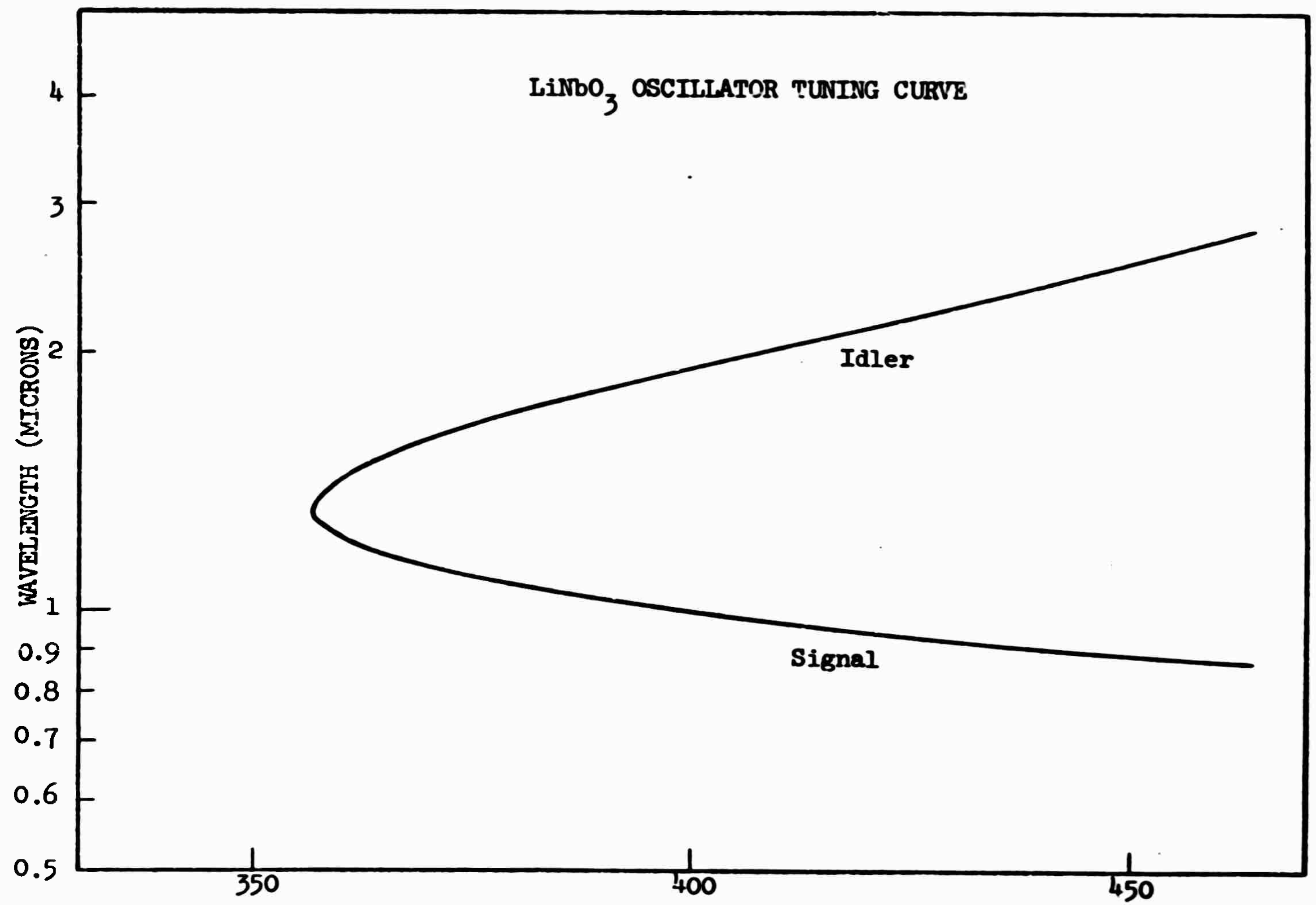

FIG. 2--$LiNbO_3$ parametric oscillator temperature tuning curve for a 0.659 μ pump wavelength.

1) Looking at the crystal with the infrared Snooperscope to check for gross inhomogeneties, cracks and impurties.

2) A transmission test from 2.5 to 12 microns to accurately measure the amount of absorption over the region in which the oscillator is to be used.

3) Isogyre test to check for crystal orientation and C-axis wandering.

When the first two crystals were received they were checked using the above procedure. Neither crystal passed the first test. One crystal was almost opaque while the other contained a large inhomogeneous region. To this date only one other crystal has been received and this contained a large crack and it also had C-axis wandering. The companies supplying the crystals are checking the problems and are hopeful of obtaining good crystals soon.

Once again the severe quality requirements of optical nonlinear crystals has meant that standard quality materials from commercial suppliers has failed to meet the specifications. We are hopeful that the companies can grow better crystals in the near future, but if that is not possible, we are prepared to grow CdSe crystal at the CMR facility on Stanford Campus. Unfortunately, this could mean a delay in constructing the CdSe parametric oscillator and infrared up converter.

Another problem has been mirror coatings in the 5 to 6 micron region. Seen from the tuning curve, a 2.7 micron pump leads to signal and idler wavelengths that occur at 4.85 and 6.2 microns respectively. Thus a simple double resonant oscillator could be made with mirrors that had a broadband coating centered at 5.5 microns. This would give an oscillator with lower threshold and faster buildup time. The requirements on the mirrors for this oscillator would be highly reflecting at 5.5 microns and

transmitting at 2.7 microns. Originally we planned to use fused silica mirror substrates as these were obtainable in ½ inch diameter by 2.5 cm radius of curvature sizes as an off the shelf product. However, it was found to be impossible to get these mirrors coated to our requirements because the low index of fused silica demanded a large number of fairly thick coating layers.

We have since turned to germanium as a substrate since its much higher index requires fewer coatings for the same reflectivity and because germanium has been commerically coated for this wavelength region. We are presently waiting for the specifications of coated germanium mirrors along with cost estimates to see if the double resonant oscillator is still feasible.

With the details of the oscillator components holding up immediate progress, we plan to pursue the pressure phasematching of the parametric oscillator and the 10.6 μ infrared up converter. To do this, we will use the parametric fluorescence technique to measure tuning curves and crystal nonlinearity. With its high nonlinearity and burning power density, and with some improvement in crystal quality, we think that CdSe is still the best nonlinear optical material available for the 1.3 to 13 μ spectral region.

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